Institut für Parasitologie
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New insights into the diagnosis of cysticercoses in cattle and sheep at population and herd level

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Summary

Ruminants are intermediate hosts of several cestodes including *Taenia saginata* in cattle and *T. ovis* in sheep. Larval stages of these cestodes manifest as cystic lesions in skeletal and heart muscle. Cysticercosis causes economic losses due to demotion or condemnation of infected carcasses. Because of the known low diagnostic sensitivity of the standard EU meat inspection protocol for the detection of *T. saginata* cysticerci, we performed an abattoir trial aiming to increase the detection rate. With the EU-approved meat inspection, bovine cysticercosis was diagnosed in 1.8% (20/1088) of the slaughtered animals. Additional incisions into the heart muscle revealed a further 29 cases, indicating a prevalence of at least 4.5%. Recently developed diagnostic strategies were applied as tools for risk management for an extended cysticercosis storm in a large sheep flock in Southwest England. At abattoir, 7% of the slaughtered lambs had been rejected due to *T. ovis* infection which was confirmed morphologically and genetically. To track the source of infection, 50 dog faecal samples collected from trails were analysed by *Taeniid*-egg isolation and further molecular specification. Further faecal samples from dogs, foxes and badgers from all farm fields were also investigated. Eventually, an egg-contaminated pasture could be identified which is frequently visited by dog walkers and which is the only common field where all the lambs have been grazed.

Zusammenfassung

Wiederkäuer sind Zwischenwirte für verschiedene Bandwürmer einschliesslich *Taenia saginata* beim Rind und *T. ovis* beim Schaf. Larvale Stadien manifestieren sich als Zysten in der Skelett- und Herzmuskulatur. Die Cysticercose verursacht wirtschaftliche Verluste durch Herabstufung und Beschlagnahmung von infizierten Schlachttierkörpern. Wegen der bekannt geringen Sensitivität der standardmässigen EU-Fleischinspektionsmethode für den *T. saginata* Zystennachweis wurde ein Schlachthofversuch mit dem Ziel einer verbesserten Befundrate durchgeführt. Mit der EU-anerkannten Fleischinspektion wurde in 1.8% (20/1088) der Schlachttiere bovine Cysticercose diagnostiziert. Mit vermehrten Herzschnitten konnten 29 zusätzliche Fälle entdeckt werden, was einer Prävalenz von mindestens 4.5% entspricht. Neuste diagnostische Methoden dienten als Werkzeug für ein Risikomanagement eines ausgedehnten Cysticercose-Sturms in einer grossen Schafherde in Südwest-England. Am Schlachthof waren 7% der Schlachtlämmer wegen *T. ovis* Infektionen abgewiesen worden, welche morphologisch und genetisch bestätigt wurden. Um die Infektionsquelle zu finden, wurden aus 50 Hunde-Kotproben von Spazierwegen Taeniiden-Eier isoliert und genetisch identifiziert. Weitere Kotproben von Hunden, Füchsen und Dachsen von allen Feldern wurden untersucht. Die kontaminierte Fläche konnte auf ein Feld eingegrenzt werden, welches von Hundehaltern stark frequentiert und als einziges von allen Lämmern beweidet wurde.

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Increased sensitivity for the diagnosis of *Taenia saginata* cysticercus infection by additional heart examination compared to the EU-approved routine meat inspection

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ABSTRACT

In spite of the statutory meat inspection at abattoirs, *Taenia saginata* cysticercus infection in cattle remains an economically important parasitic disease for the livestock industry by affecting food safety. The routinely performed standard meat inspection protocol has a low diagnostic sensitivity for the detection of *T. saginata* cysticerci infections. Therefore, an abattoir trial aiming to increase the detection level was undertaken. In three EU-approved abattoirs, several additional heart incisions were performed in a total of 1088 slaughtered cattle originating from 832 farms throughout Switzerland. Cysticerci as putative parasitic lesions were classified by visual examination during meat inspection and confirmed microscopically and/or by molecular analyses. With the EU-approved routine meat inspection, bovine cysticercosis was diagnosed in 1.8% (20/1088) of the slaughtered animals. Additional incisions into the heart muscle revealed a further 29 cases, indicating that the prevalence was at least 4.5%. All infected animals originated from individual farms. This straightforward technique had a significantly higher sensitivity and is feasible for routine practice. It also confirms that the prevalence of this zoonotic parasite in the cattle population is underestimated based on the routine abattoir reports.

1. Introduction

Taenia saginata is the most common tapeworm in humans (as final host) in central Europe, and cattle are the only intermediate host. Despite very low incidences in Europe and low morbidity in humans (Murrell, 2005), *T. saginata* cysticercus (Cysticercus bovis) infection in cattle represents an unsolved problem with respect to food safety, generating financial losses (Berends, Snijders, & van Logtestijn, 1993; Saini, Webert, & McCaskey, 1997). The carcasses of animals found to be infected are downgraded requiring extra handling and freezing, or they are even condemned if heavily infected. In Europe, prevalences of 0.007–6.8%, based on abattoir data, have been reported (Anonymous, 2005a). Naturally infected animals in Europe generally have a low cyst-burden (Geerts, Kumar, Ceulemans, & Mortelmans, 1981; McCool, 1979), which is characteristical for transmission by contaminated forage or water (Boone et al., 2007; Flütsch et al., 2008).

According to the EU-legislation, the legal routine meat inspection for the diagnosis of *T. saginata* cysticercus infection in slaughtered cattle at abattoir includes, for each animal, visual examination of the oesophagus, the diaphragm, tongue (additional palpation of the tongue is also required) and the heart, respectively. Furthermore, this regulation prescribes two cuts into the masseter muscles on both sides, one incision in the inner cheek muscles (pterygoideus lat. and med.) and at least two longitudinal cuts in the heart muscle, followed by visual examination for the presence of parasitic lesions (Anonymous, 2005a). The sensitivity of this visual search for parasitic cysts is roughly estimated to be 10–50% (Dewhirst, Cramer, & Sheldon, 1967; Dorny et al., 2000; Geerts, Kumar, & van den Abbeele, 1980; McCool, 1979; Murrell, 2005; Walther & Koske, 1980).

Cattle are infected by ingestion of tapeworm eggs of human origin. *Taenia saginata* cysticerci are located mainly in muscle tissues with high metabolic activity, in particular diverse skeletal and the heart muscles (Maeda, Kyvsgaard, Nansen, & Bøgh, 1996). The cheek and heart muscles are frequently infected sites and hence are targeted during meat inspection (Dewhirst et al., 1967; Geerts et al., 1980; Juranek, Forbes, & Keller, 1976; Kyvsgaard, Ilsoe, Henriksen, & Nansen, 1990; Lopes et al., in press; Maeda et al., 1996; Pugh & Chambers, 1989; Scandrett et al., 2009).

As additional cuts in the masticator muscles are not feasible at meat inspection, extended investigation of the heart muscle has

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a potential to increase the inspected muscle surface and hence the sensitivity. Cysticerci in the cardiac muscle live for a shorter period than in other muscles and are gradually resorbed (Gallie & Sewell, 1983; Geerts et al., 1980; Harrison, Gallie, & Sewell, 1984; Juranek et al., 1976; Scandrett et al., 2009; Stěrba & Dyková, 1978; Stěrba, Dyková, & Machnicka, 1979), leaving calcified cysts which are easy to detect. Furthermore, as the heart is not a valuable part of the carcass, heart incisions during meat inspection result in less economic loss as compared to other possible inspection sites (e.g. heart muscle is often applied for sausage production, whereby handling at meat inspection does not affect the final product). This study aimed to investigate whether the sensitivity of the EU-approved routine meat inspection for the diagnosis of *T. saginata* cysticercus infections can be increased whilst minimising additional damages to the carcass. Furthermore, the risk factor animal age and gender were analysed.

2. Materials and methods

2.1. Study design

Three EU-approved abattoirs, located in different parts of Switzerland, were visited on 16 occasions between November 2008 and October 2009. The abattoir trial was performed in collaboration with the local meat inspectors and under normal inspection conditions (procedure, conveyor speed, light performance, space available) and at the time of slaughter. Slaughtered animals originated from 832 farms throughout Switzerland. Calves and feeder cattle were excluded from the study, remaining a total of 1088 investigated slaughtered cattle.

2.2. Meat inspection protocol

At the abattoir, EU-approved routine meat inspection (European Council Directive 95/23/EC of 22 June 1995 amending Directive 64/433/EEC on conditions for the production and marketing of fresh meat) was performed first by the local meat inspectors, followed immediately by enhanced heart exanimation. Six additional heart cuts were performed, to investigate a maximal additional cutting area, followed by visual examination for the presence of parasitic lesions. Three cuts were performed each (shallow-, median- or deep) in parallel to the Facies auricularis and Facies atrialis of the heart (approx. 0.5–1 cm apart), respectively.

Hearts from all infected carcasses (diagnosed by routine and enhanced meat inspection) were transported to the laboratory for further comprehensive heart examination of the entire heart by complete dissection into 0.5 cm thin slices. All cysticerci were collected for laboratory confirmation, and the number of cysts in the different inspected parts was recorded.

2.3. Laboratory-based confirmation of positive abattoir results

To confirm the visual diagnosis, lesions were further analysed. Firm, thin-walled, bullous cysts with a single unarmed scolex were microscopically categorised as viable cysticerci. Cystic lesions with a caseous, intransparent or calcified content were classified as dead cysts, and a *Taenia*-specific polymerase chain reaction (PCR) was done on these cysts. DNA was isolated using a commercial kit (Qiamp DNA mini kit, Qiagen, Hilden, Germany), according to the manufacturer's instruction. DNA amplification was performed as described (Flütsch et al., 2008) using the *Taenia*-specific primers Cest3/5 (Trachsel, Deplazes, & Mathis, 2007). All samples were tested in duplicates using 25 μl and 2 μl of the extracted DNA.

2.4. Data input and processing

Using the official Swiss cattle database (Identitas AG), sex and age of each slaughtered individual animal, encoded by ear tags, were collected. Carcasses found to be infected were listed with respect to the number and location of cysticerci. For data analysis, a commercial spreadsheet application (MS Office Excel 2007) and a statistical software package (SPSS Statistics 17.0.0) were used. Logistic regression analysis was performed to explore relationships with age, sex, and infection status. Infection status (positive or negative and viability of the cysticerci at meat inspection including the enhanced heart examination) was set as 'responsive variable'.

3. Results

Data obtained from the three involved EU-approved abattoirs by either routinely performed meat inspection or enhanced heart examination are summarised in Table 1. The legal routine procedure identified 1.8% of the animals (20/1088) harbouring cysticerci. With the enhanced investigation, more than twice as many infected animals were detected, yielding an apparent prevalence of the investigated group of 4.5% (49/1088). All infected animals originated from different farms. From the inspected cattle, 43 of 880 (4.9%, CI95%: 3.6–6.6%) female and 6 of 208 (2.9%, CI95%: 1.2–6.5%) male animals were infected.

Details of the collected cysticerci by routine meat inspection and enhanced heart examination are summarised in Table 2. The legal routine meat inspection identified in 18 of the 20 positive carcasses a single cyst. Furthermore, in none of the routinely diagnosed cysticerci infection further lesions were detected by the enhanced heart examination. In 45 (91.8%) of the 49 infected animals, only a single cyst was identified either by routine meat inspection or by enhanced heart examination, respectively. Nevertheless, comprehensive examination by complete dissection of the entire hearts of 45 animals diagnosed with only one cyst by the preceding inspections revealed in 13 (28.9%) additional lesions. However, only one of 14 animals with single cysticerci in the masticatory muscle showed additional lesions in the heart. In 4 carcasses (2 detected by

Table 1
Diagnosis of *Taenia saginata* cysticercosis in 1088 cattle slaughtered in 3 EU-approved abattoirs (A-C) in Switzerland. Number of infected animals detected either by the legal routine meat inspection or by enhanced heart examination.

Abattoir[a]	A	B	C	Total
Cattle investigated:	259	312	517	
Positive at routine meat inspection:				
Masticator muscles only	3	4	7	14
Heart only	1	1	2	4
Multiple cyst infection[b]	1	0	1	2
Total	5 (1.9%)	5 (1.6%)	10 (1.9%)	20 (1.8%)
Positive at enhanced heart examination[c]:				
Heart surface[d]	4	1	0	5
Cut 1 (shallow)[e]	1	0	0	1
Cut 2 (median)[e]	3	4	4	11
Cut 3 (deep)[e]	5	1	1	7
Cut 4 (shallow)[e]	1	1	1	3
Cut 5 (median)[e]	0	0	1	1
Cut 6 (deep)[e]	0	0	1	1
Total	14 (5.4%)	7 (2.2%)	8 (1.5%)	29 (2.7%)
Grand total of number infected:				
	19 (7.3%)	12 (3.8%)	18 (3.5%)	49 (4.5%)

[a] Encoded by letters with respect to data privacy.
[b] More than one detected parasitic lesion at the normal routine inspection sites.
[c] In none of the routinely diagnosed infection further cysticerci were found by the enhanced heart examination.
[d] Missed at routine meat inspection.
[e] Three cuts were performed each (shallow-, median- or deep) in parallel to the Facies auricularis (cut 1 to 3) and Facies atrialis (cut 4 to 6) of the heart, respectively.

Table 2
Infection sites and status (viable or dead) of *Taenia saginata* cysticerci ($N = 103$) in 49 infected cattle detected either by the legal routine meat inspection or by the enhanced heart examination.

	Single cyst infection		Multiple cyst infection[a]	
	viable	dead	viable	dead
Cysticerci detected at routine meat inspection:				
Masticator muscles	11	3	5	0
Heart	2	2	1	0
Comprehensive examination of hearts positive at routine meat inspection[b]:				
	6	1	25	4
Cysticerci detected at enhanced heart examination[c]:				
Heart surface[d]	2	3		
Additional cuts	5	17	1	3
Comprehensive exanimation of hearts positive at enhanced inspection[b]:				
	5	7	0	0

[a] More than one cysticerci detected by the routine or enhanced inspection.
[b] Comprehensive heart examination of the entire heart from all infected animals by complete dissection into 0.5 cm thin slices.
[c] In none of the routinely diagnosed infection further cysticerci were found by the enhanced heart examination.
[d] Missed at routine meat inspection.

routine meat inspection) more than one cysticercus were detected at the inspection sites (multiple cyst infection). The two cases of multiple cyst infection detected by enhanced heart examination had both two cysts close-by at cut number 3, respectively. In total, 103 cysticerci were collected including 63 of a viable status (61.2%). All in all, single viable cysticerci were detected in 78.6% (CI95%: 48.8–94.3%) at the masticatory muscles and in 40% (CI95%: 26.7–54.8%) at the heart muscle. Concurrent infections with viable and dead cysts were detected in 8 animals. The findings using enhanced heart examination at meat inspection are illustrated in Fig. 1. For instance, 91.7% of the additionally identified cases were detected by four ancillary heart cuts.

All cysts classified as viable at routine meat inspection or during the enhanced examination could be confirmed by further microscopical and/or molecular analysis. In contrast, 8 of 40 caseous, intransparent or calcified alterations (died off cysticerci) yielded a negative PCR result (3 detected by the routine protocol, 3 by enhanced heart examination, and 2 by comprehensive examination of the entire heart).

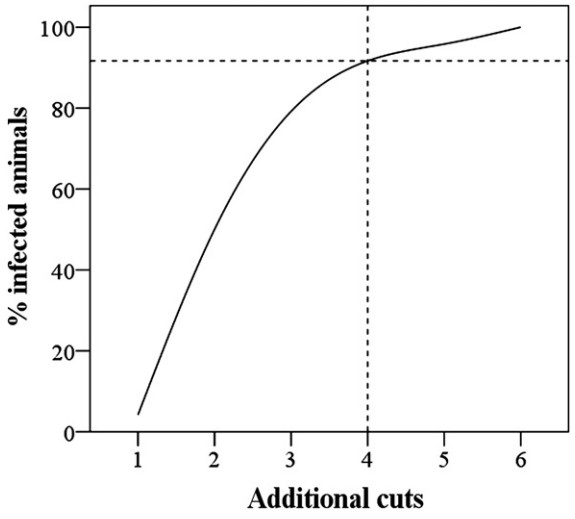

Fig. 1. Enhanced heart examinations after routinely performed standard EU-approved meat inspection: Relation of additively diagnosed carcasses (N=29) with *Taenia saginata* cysticercus infection in slaughtered cattle in function of 6 additionally performed heart muscle cuts.

The logistic regression analysis showed a relation between age and infection status. Older animals had a significant higher probability to be infected ($p = 0.014$). There was no determinable correlation of age and appearance of the cysticerci (vital or died off cysticerci) as well as gender and infection status, or gender and appearance of the lesions ($p > 0.05$).

4. Discussion

A method to increase the sensitivity of routine meat inspection for the detection of *T. saginata* cysticercus infection in cattle in Europe is described. Meat inspection for bovine cysticercosis in Switzerland is performed analogously to EU regulation and directives (Anonymous, 2005b). The present work illustrates that more than twice as many lesions can be identified using an enhanced inspection protocol to find *T. saginata* cysticerci. This resulted in an observed prevalence of 4.5% for bovine cysticercosis as compared to 0.97% compiled from Swiss abattoir reports (data from 6 abattoirs for 243336 dairy cattle slaughtered between 2002 and 2005). This is comparable to other reports from Europe which suggests that routine inspection underestimates the prevalence by a factor of 3–10 (Dorny et al., 2000; Geerts et al., 1981; Hörchner, 1983; Kyvsgaard et al., 1990). During this investigation twice the prevalence was determined by the local meat inspectors when an additional external investigator was present. This indicates that the meat inspectors participating in the present study were more meticulous than usual because of our presence in the abattoirs. Psychological factors have been hypothesised to influence the sensitivity of the meat inspection (Dorny & Praet, 2007). On the other hand, the morphology of the lesion (viable or dead) had no influence on the detection rate at the routine or additional meat inspection, unlike earlier experiences (Geerts et al., 1980).

Several reports on the distribution pattern (occurrence and density) of cysticerci, either in experimentally infected animals or in animals originating from highly endemic regions point to the heart as an appropriate inspection site for the detection of *T. saginata* cysticerci in cattle (Juranek et al., 1976; Kyvsgaard et al., 1990; Maeda et al., 1996; Pugh & Chambers, 1989; Scandrett et al., 2009). Comparably, in Belgium 25% measly cattle have been detected by total heart dissection of 100 inspected carcasses (Geerts et al., 1980). The present work has demonstrated the effectiveness of a simple technique to be applied in regions where the epidemiological data suggests low cyst-burdens and where increasing the diagnostic sensitivity by accurate inspections of the heart is important. The majority of animals found to be infected were detected by examination of masticatory muscle at routine meat inspection, and only one of these cases had additional lesions in the heart. Nevertheless, the 29 additional carcasses discovered with cysticercus infections by the enhanced heart examination underlines the requirement of a multiple organ investigation at meat inspection (Scandrett et al., 2009).

Our data of 78.6% viable cysticerci in the masticator muscle compared to 40% in the heart muscle confirms that cysticerci in the myocardium undergo early degeneration as described earlier (Geerts et al., 1980; Stěrba et al., 1979). Viable and dead cysts were concurrently found in the heart of eight animals, confirming older data (Gerber, 1991; Hörchner, 1983; Juranek et al., 1976).

All cysts classified as viable during the routine meat inspection or detected by additional investigations were confirmed as *T. saginata* cysticerci by morphology and molecular means. However, amplification of *Taenia*-specific DNA was unsuccessful from 8 of 40 calcified lesions. A comparable low sensitivity of PCR on calcified lesions was reported (Abuseir, Epe, Schnieder, Klein, & Kühne, 2006; Chiesa et al., 2010; Geysen et al., 2007; Harrison et al., 2005). There was no difference in view of negative PCR results in lesions found by routine or enhanced investigations.

The sex ratio of slaughtered animals in our study is in agreement with official statistical abattoir data for Switzerland, with 66.4 female and 33.6% male (+/− 2.7) animals (data from Swiss federal agency for statistics, 1995 to 2003). In the livestock industry of Switzerland female cattle usually grow older than male animals. There is evidence that older cattle have a significant higher risk to be infected. In an epidemiological situation with low infection pressure, exposure time and age of animal increase the risk of infection (Dorny et al., 2000). However, in the current study no significant correlation between gender and infection status was observed. A possible explanation of this result is that feeder cattle (e.g. with a high proportion of male cattle) were excluded from the study, and that the investigated group included male animals reared under comparable conditions as cows.

5. Conclusion

The current study confirms a low sensitivity of the EU-approved routine meat inspection for *T. saginata* cysticercus infections. An enhanced but practical heart investigation minimising additional damages to the carcass increased the sensitivity more than twice. Therefore, additional heart cuts during the routine meat inspection should be recommended in endemic regions to minimise parasitic transmission.

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Short Communications

Severe *Taenia ovis* outbreak in a sheep flock in south-west England

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SMALL ruminants are the intermediate host of several canine tapeworm species, including *Taenia ovis*. In sheep, the larval stages of this cestode (previously called *Cysticercus ovis*) manifest as cystic lesions. *T ovis* infection in sheep has been reported to be endemic in parts of Great Britain (Jones and Walters 1992, Green and others 1995), but up-to-date epidemiological data are scarce. The English sheep industry suffers annual economic losses of over £7 million due to the presence of *T ovis* cysts and subsequent condemnation of the carcases at the abattoir (English Beef and Lamb Executive [EBLEX] 2011).

The adult stage of *T ovis* is found in the intestine of canids, particularly dogs, foxes and wolves. Sheep become infected with eggs on contaminated pastures, and the larval stages develop in skeletal and heart muscle. The parasitic cycle is completed when the definitive host ingests viable cysts. This short communication describes an extended severe outbreak of cysticercosis in a large sheep flock in Somerset, south-west England.

In 2009, 7 per cent (600 of 9000) of the slaughtered sheep from a farm were rejected at abattoir inspection due to cysticercosis. In April 2010, lesions from six hearts of condemned carcases were analysed morphologically (Fig 1) and by a *Taenia*-specific PCR followed by sequence analysis (Trachsel and others 2007), resulting in the diagnosis of *T ovis* infection.

The affected farm consisted of 103 ha (258 acres), split into small units that were partially divided by fences or hedges. There was a complete boundary fence (made partly of barbed wire or stone walls). Several public footbaths cross the pastures. On the farm there were 650 dairy cattle, a number of ducks and pheasants, and a cat. All seven farm dogs (including two sheepdogs) were regularly dewormed with a medication containing praziquantel, and they were fed strictly on commercially formulated diets. During the summer and autumn, the farmer bought up to 12,000 spring-born lambs (aged between three and five months), originating from all over the UK. Only a few lambs were homebred. The lambs were delivered to one specific field near the farm (called the 'home field') where all the animals were checked by the farmer and treated against intestinal parasites. Lambs were classified by size and organised in groups of 100 to 300 lambs per flock. Before slaughter the following spring, most of the lambs were outsourced for grazing to other farms, except for approximately 1200 lambs that remained on the main farm.

Initially, possible sources and routes of transmission were investigated. In June 2010, faecal samples from all the farm dogs were examined coproscopically for the presence of *Taenia* species eggs using the sensitive flotation and sieving method (Mathis and others 1996). Fifty dog faecal samples were collected by the farmer on the pastures located close to neighbouring built-up areas, which are attractive sites for dog walking. Taeniid egg isolation and further molecular speciation revealed one faecal sample, originating from the home field, to be positive for *T ovis*.

It was known that foxes hunted and scavenged young and casualty lambs on the pastures. In late June, four culled foxes from the farmland were investigated for intestinal cestodes, using the sedimentation and counting test (Hofer and others 2000). No sheep-related parasites were identified. However, the fox tapeworm *Taenia polyacantha*, which uses microtine rodents as intermediate hosts, was found in two of the foxes.

To identify possible risk factors for the infection of sheep, information was collected in July 2010 on farm management, animal handling and healthcare, slaughtering, and the local environment. This was based on a structured personal interview with the farmer modified from the method of Flütsch and others (2008). It was concluded that the contamination of the pastures needed to be addressed. All the farm fields were visited and faecal samples from carnivores were collected for taeniid egg isolation. From eight fields, pools of dog faecal samples were analysed as well as eight fox samples and one badger sample (Fig 2). The pooled dog sample from the home field was positive for *T ovis* as confirmed by PCR and sequencing. All the other samples were negative for *Taenia* species, except two fox samples positive for *T polyacantha*.

The home field contaminated with *T ovis* eggs was the only common place for all the purchased and the homebred lambs. The extent of contamination with parasite stages might have been greater than was revealed by the two independent investigations. Eggs and proglottids of tapeworms are excreted into the environment by defecation. However, a study of six dogs experimentally infected with *Taenia hydatigena* revealed that 64 per cent of all proglottids shed during patency were released without defecation (Deplazes and Eckert 1988), and this might also be the case for *T ovis*.

Other outbreaks of cysticercosis in sheep flocks have been found to be caused by infected farm dogs. For example, in Canada, lambs originating from four farms were infected with *T ovis* from dogs trained on a fifth farm (Soehl 1984). In Switzerland, a case of fatal coenurosis caused by imported sheepdogs was described by Schweizer and others (2006). It is known that one infected dog can spread eggs for several years, representing a persistent source of infection (Gregory 1978).

An endemic state of taeniid infection characterised by infrequent exposure to the parasite implies that the infection cannot be controlled by naturally acquired immunity. This may result in cysticercosis 'storms' with sudden high infection rates (Roberts and others 1987, Gemmell and others 1990, Cabrera and others 1995).

The pastoral landscape in Somerset allows for a high density of foxes, of 1.5 to 2.4 foxes per square kilometre (Webbon and others 2004). Nevertheless, in the present study no sheep-related parasite could be identified in foxes. On the other hand, the home field was frequently visited by dog walkers from a nearby built-up area, and this represents a high risk for *T ovis* egg transmission. Cleaning up pet dog faeces on public footpaths reduces the environmental contamination with infective parasitic stages. Important preventive measures include regular anthelminthic treatments and/or diagnostic testing of domestic dogs. Current guidelines and expert opinion on parasite control specific for the UK and other European countries are available from the European Scientific Counsel for Companion Animal Parasites (ESCCAP 2011).

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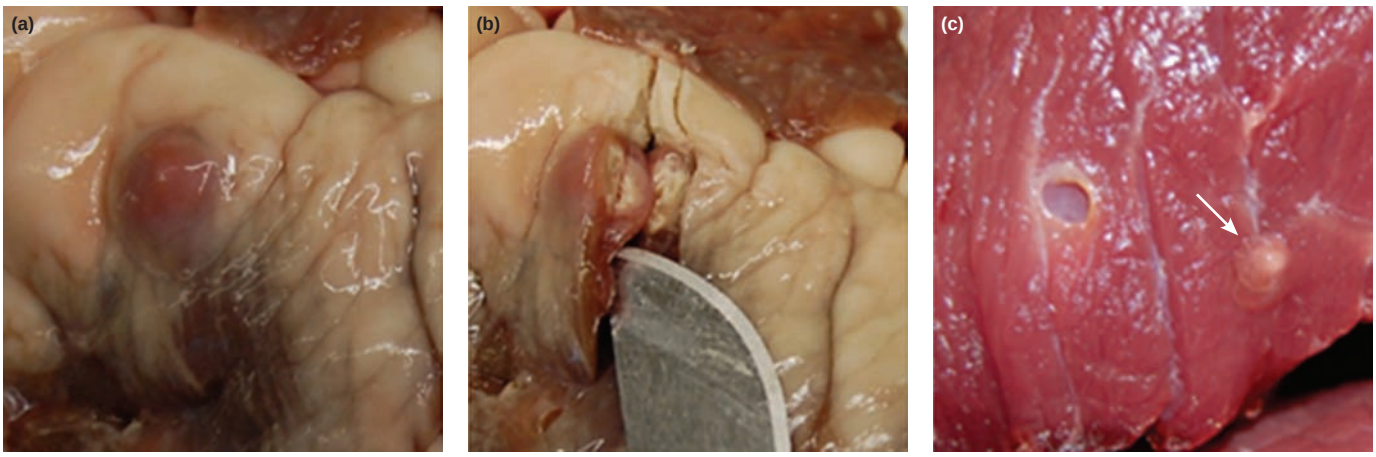

FIG 1: *Taenia ovis* lesions in sheep condemned at slaughter. (a) Non-viable lesion in heart muscle (size 4 to 5 mm). (b) Opened calcified lesion in heart muscle. (c) Viable *T ovis* larval stage (arrow) adjacent to an empty fibrous capsule in the masseter muscle

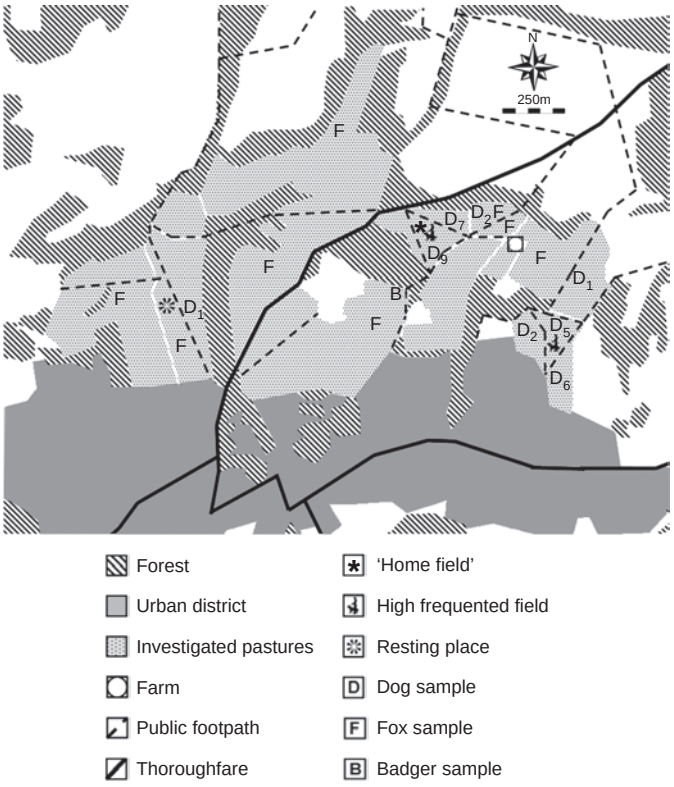

FIG 2: Map of area on and around a farm investigated following a large severe outbreak of *Taenia ovis* infection in lambs. D Location of pooled dog faecal samples (number illustrates individual samples), F Location of eight individual fox faecal samples, B Badger faecal sample

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